Assessment of degraded mattoral land using remote sensing imagery in Guadalteba Area, Spain

XING Yan-qiu[1], WANG Li-hai[1], Eduard Westinga[2]
[1]College of Engineering and technology, Northeast Forestry University, Harbin 150040, P. R. China
[2]International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede, Netherlands, Holland

Abstract: Natural land cover information is important for analysing and understanding of the current terrestrial situation, especially in the study area that is facing the environmental deteriorating increasingly. The study combined the remote sensing Aster data and ground truth to improve 2001 land cover map of Guadalteba area in Spain, and increased the accuracy from 47% to 70%. The general land cover map produced about the Guadalteba study area outlines the distribution of the vegetation type and the current natural land cover in the area. Based on this improved general land cover map, the natural cover map gave an indication of the present location of nature and agriculture areas. The shrub land degradation map identified location of various shrub/matorral areas and different levels of degradation. The further analysis and discussion were done. The output maps indicated that much of the natural cover mostly dominated by formations of shrubs has been changed to agriculture and other land uses. It is observed that shrubland covers a small percentage, approximately 9% of the study area, due to land degradation in most parts caused by human interfere.

Key words: Accuracy assessment; Aster; Land cover map; Matorral degradation map; Remote Sensing
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Introduction

The requirement for data of large-scale land cover and land use has increased recently, especially in rapidly growing metropolitan areas. Many state, regional, and local planning agencies require up-to-date information for various applications, including modelling urban growth, determining land suitability for future development, monitoring how land use changes influence the environment, understanding land use patterns, and development policies that could encourage or discourage development of certain land use (Iverson *et al.* 1994).

Currently, the remote sensing technique is used broadly to map the land cover, and especially the aerial photography, as one of most significant methods due to its high resolution, has been employed to assess the forest area (Hansen 1990; Loetsch & Haller 1964). However, the photographs may be expensive to be purchased and are cumbersome to acquire, transfer, handle, and store. Thus, it is limited to use in the forestland assessment. Ronald *et al.* (2002) found that the satellite imagery had been viewed as an alternative by using aerial photographs to estimate forest. The primary advantages of this alternative are its digital format, border-to-border coverage, and consistency.

EOS (Earth Observing System) is the centerpiece of NASA's Earth Science mission. The EOS SM-1 satellite, later renamed to Terra, is the flagship of the fleet and was launched in December 1999. It carries five remote sensing instruments including MODIS and ASTER. ASTER, the Advanced Spaceborne Thermal Emission, and Reflectance Radiometer, is a high resolution imaging spectrometer (International Institute for Aerospace Survey and Earth Sciences 2003a). This study employed the Aster images and random sampling approach to increase the precision of the land cover map of the study area.

In Guadalteba area of Malaga Province of Spain, many pieces of forest and shrub lands were changed to agriculture and other land uses during past decades. To improve the deteriorating environment increasingly, the local government and forestry management agency urgently need more detail and invisible information about the land cover. The results of this study will offer the reliable updated materials to the decision makers.

The overall objective of this study is to tackle the distribution at difference stages for degradation of the matorral and Oak forest in Guadalteba, and the possibilities and/or prioritisation of area for replanting schemes with local matorral and/or tree species. To meet the overall objective, the expected outputs of the research were prescribed as following:

- An accuracy assessment of land cover 2001 map and its improvement (updated land cover map 2001).
- A matorral (shrubland) degradation map.

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Biography: XING Yan-qiu (1970-), female, Lecturer, in College of Engineering and technology Northeast Forestry University, Harbin 150040, P. R. China. **Email**: yanqiuxing@yahoo.com.cn
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Study area

Guadalteba is located in Malaga Province in the south of Spain (see Fig.1). The area is approximately 725 km^2 and the population in 2000 was about 26 000.

The climate in the study area is thermo-Mediterranean, characterized by dry summers and wet winters. Annual average temperature ranges from 4°C to 35°C. Mean annual precipitation varies from 400 mm to 700 mm (International Institute for Aerospace Survey and Earth Sciences 2002; International Institute for Aerospace Survey and Earth Sciences 2003b).

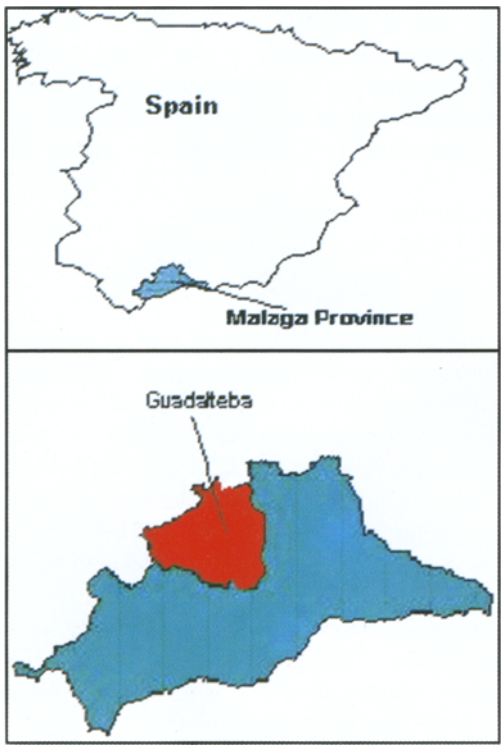


Fig.1 Location of study area in Spain

Data collecting and study method

On the accuracy assessment and improvement for land cover 2001, the following data sets were used:

- Point data for 2001, 2002 and 2003 (ground truth).
- Land cover map 2001 (see Fig. 2).
- Aster image dated 1 February 2001 and 22 June 2001.
- Topographic map/s (1:50 000).

For the collection of additional ground truth 2003, Aster images (in June 2001, 321 RGB) and land cover 2001 were used as the base materials. Homogenous units/areas that exhibited vegetation reflectance characteristics on a false colour composite (e.g. bright red, magenta, greenish etc.) were identified on the images and then sampled using a Stratified Representative Sampling Strategy in the field (Westinga 2001). Then 2001, 2002 and 2003 ground truth data for all cover types were combined to assess the accuracy of land cover map 2001.

To improve land cover mapping, major vegetation units were identified and manually delineated on a transparent overlay using the June 2001 Aster image, and then on-screen digitised for the purpose of showing natural cover versus agriculture areas.

Matorral degradation map was produced from the improved 2001 land cover map by use of map calculation process.

The improvement of the agriculture part of the map (especially olive layer) was based on Topomaps 1: 10 000, ground truth 2003 and the Aster Image June 2001. The natural cover and agricultural layers were finally combined into a general improved land cover map (Fig. 3).

Results and discussion

Accuracy assessment and general improved land cover map

Based on field observations and the ground truth data in the assessment of the 2001 land cover map, it was identified that several classification errors had been resulted.

Using the combined point data (2001–2003), a correlation matrix was generated and the overall accuracy of the Land cover Map 2001 was 47%. Since this was considered low (based on a threshold of 60% accuracy), an improvement in the mapping was then necessary.

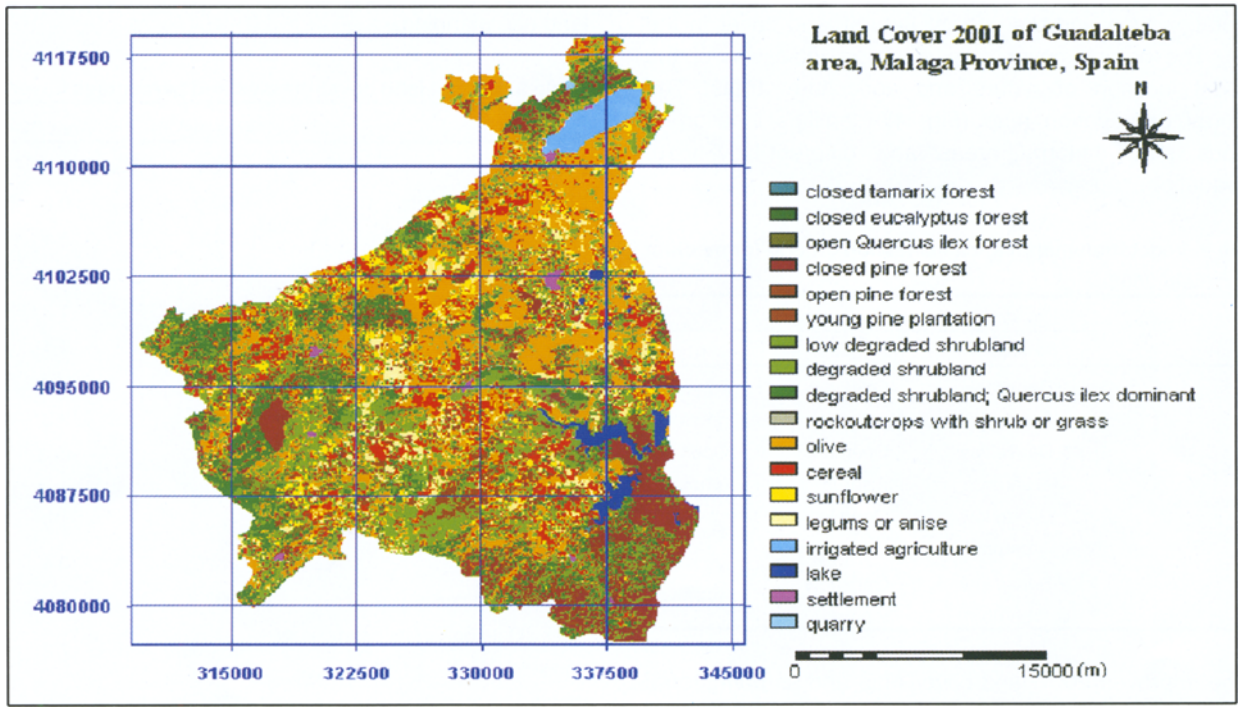
The improved general land cover map was also checked for accuracy using the same combined ground truth and its overall performance was 71%.

Matorral degradation map

The main aim of the study was to map the different matorral (shrubland degradation stages) and improve on its classification in the 2001 cover map. Using the criteria (Table 1 and Table 2), a new classification system based on a combination of vegetation structure and species composition/dominance was adopted. Different degradation stages can thus be derived based on this system e.g. 'low shrubs' are considered a higher degradation stage as compared to 'high shrubs and woodland' or 'Open Quercus Ilex forest' etc. (Table 3).

Table 1. Vegetation mapping classification criteria for high layer, Field 2003

		Tree cover /%		
		>40	10-40	<10
Shrub cover /%	>40	Dense forest	Open forest	Dense high shrub
	10-40	Dense forest	Open forest	Open high shrub
	<10	Dense forest	Open forest	Low shrub (medium layer)



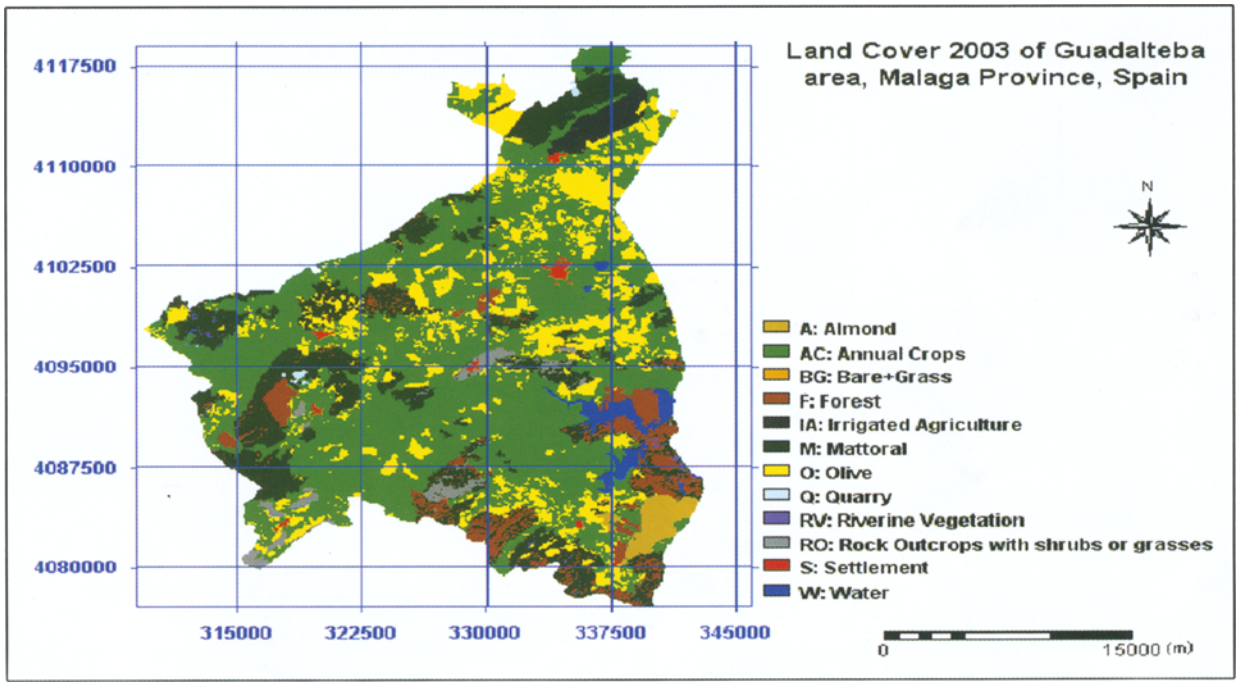


Fig. 3 Improved land cover map, Guadalteba, Spain

Conclusions

The maps indicated that much of the natural cover mostly dominated by shrubs has been changed to agriculture and other land uses. It is observed that shrubland covers a small percentage, approximately 9% of the study area, due to degradation in most parts caused by human interference, such as overgrazing, fire, agricultural expansion, and infrastructure expansion. Much of the natural forests has been exploited for various uses, thus, the planted forests dominate the current forest areas.

The general land cover map produced about the Guadalteba study area outlines the distribution of the vegetation type and the current natural land cover in the area. The natural cover map gives an indication of the present location of nature and agriculture areas. The matorral degradation map (Fig. 4) identifies location of various shrub/matorral areas and different levels of degradation.

Table 2. Vegetation mapping classification criteria for medium layer, Field 2003

		Shrub cover /%		
		>40	10-40	<10
Grass cover /%	>40	Dense low shrub	Open low shrub	Dense grass
	10-40	Dense low shrub	Open low shrub	Open grass
	<10	Dense low shrub	Open low shrub	Bare
	<10	Dense low shrub	Open low shrub	Bare

The improved 2001 land cover map and shrub/matorral map can be used as tools for resources assessment in the planning and land cover/use change monitoring, and contribute positively to the Guadalteba Land use Plan. The output can also be used by authorities at various levels in the project area to develop further activities in the area of land use planning.

Table 3. Natural land cover classes and percentage coverage

Classes	Area /hm^2	Area /%
Bare + Grass	62.7	0.3
Closed Q. Ilex Forest	33.9	0.2
Dense Pine Forest	1813.5	8.1
Dense Tamarix Forest	32.4	0.1
Grasses + Low Shrubs	277.7	1.2
High Shrub + Woodland	917.9	4.1
Low Shrub + Ilex	2922.1	13.1
Low Shrub + Olea Sylvestris	727.4	3.3
Low Shrubs	9428.0	42.3
Open Pine Forest	2338.0	10.5
Open Q. Ilex Forest	369.8	1.7
Quarry	90.5	0.4
Riverine Vegetation	363.8	1.6
Rock Outcrops with shrubs or grasses	1613.8	7.2
Water	1314.9	5.9
Total	22306.4	100.0

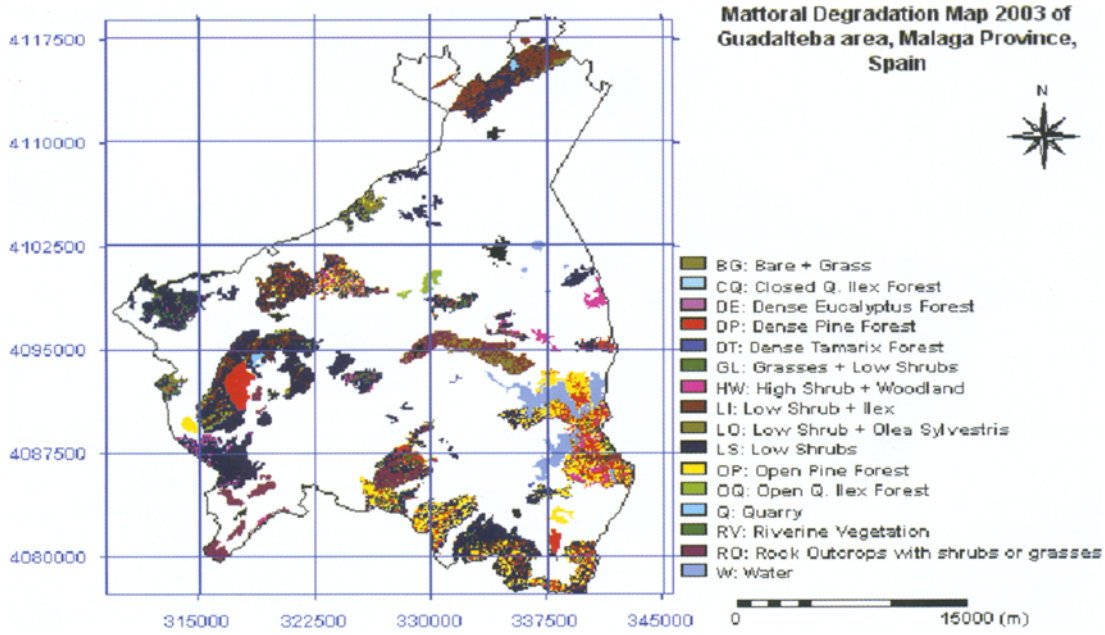


Fig.4 Matorral degradation map

Recommendations

It has been observed that almost all land adapted to agriculture in the sub-district of Guadalteba is being utilized. Forest and mottorals are therefore mainly found on mountains with steep slopes that make most of the natural areas inaccessible and were thus not sampled during the fieldworks of the past three years, including fieldwork in 2003. Because of this, all natural units were delineated on the image based on other units of similar colours and patterns.

Supervised classification that was used for mapping different vegetation types and degradation stages per unit was also found unreliable, especially on the units where samples were not taken, as different vegetation types with more or less similar colours could sometimes be classified as one class.

It is therefore recommended that when doing vegetation mapping in this types of landscapes a group should concentrate on the same vegetation types (e.g. forest) so that more points could be sampled in each vegetation class even on the steeper slopes, for a more accurate land cover map. However, with the hold of field observation units, delineation of natural units for the supervised classification per unit was proven to be useful to restrict wrong classification even outside natural areas and is highly recommended for future vegetation mapping of this kind.

Environmental education on the population of Guadalteba is recommended to make a better management of natural resources. This should be supplemented by public awareness on the importance of shrub land in the area. Nurseries for planting the degraded areas are also recommended to recover indigenous species in all the Municipalities.

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